University of Massachusetts Amherst

Spring 2003

Significant BITS

Newsletter of the
Department of Computer Science

Can computers think too much?

How does an artificial agent know what is the "right" amount of thinking to do before taking action? This is the focus of some of the research now being conducted in the Resource Bounded Reasoning (RBR) Lab under the leadership of Associate Professor Shlomo Zilberstein.

The need to limit thinking and take action has been recognized as important since the late Herbert Simon, a distinguished economist and artificial intelligence pioneer, coined the term "satisficing" to denote decision making that searches until an alternative is found that meets the agent's aspiration level. People do this type of decision-making frequently. For example, in planning a trip, a person would rarely consider what to do in the event that the train derailed. This is because considering and arranging alternative plans for each unlikely scenario would take so much time that the trip itself would be in jeopardy. People intuitively know that this kind of planning is a poor use of time. Computers lack such common sense. Zilberstein's primary research goal has been to create efficient computational models with which to analyze the trade-off between the computer's continued deliberation on a problem and commitment to action.

An important aspect of intelligence, traditionally ignored in the development of artificial agents, is the ability of the agent to factor the cost of deliberation into the deliberation process. "Taking into account the cost of decision making is not an easy task because there is considerable uncertainty about both the costs and benefits of carrying out a computation," says Zilberstein. "The benefits relate to the expected improvement in decision quality once the computation is completed. The associated costs are not simply time, but the opportunity cost, which measures the cost of not taking an action based on the best decision that has been reached so far. We have developed models to estimate the value of computation while introducing minimal overhead."

Later this year, two powerful new Mars rovers similar to this one will be on their way to explore the red planet

One of the lab's exciting projects involves a collaboration with NASA to develop planetary rovers – small unmanned vehicles equipped with cameras and sensors used for scientific experiments – that function more autonomously and make better decisions. Autonomous control of rovers on distant planets is crucial because the

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Immerman awarded prestigious fellowships

Professor Neil Immerman was recently appointed as a Guggenheim Fellow and also a fellow of the Association for Computing Machinery (ACM). He was recognized with these prestigious fellowships for his contributions to complexity theory, descriptive complexity, and database theory.

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NEWS

UMass designated Center of Academic Excellence

The National Security Agency (NSA) has designated UMass Amherst as a Center of Academic Excellence in Information Assurance (IA) Education for academic years 2003 through 2006. UMass Amherst joins the list of 14 universities across the country to be awarded this distinction in 2003. The Departments of Computer Science and Electrical and Computer Engineering spearheaded this effort by collaborating with other departments on campus in preparing the proposal to NSA for this University-wide recognition. NSA granted the designations following a rigorous review of university applications against published criteria based on training standards established by the National Security Telecommunications and Information Systems Security Committee (NSTISSC). The program is intended to reduce vulnerabilities in the national information infrastructure by promoting higher education in information assurance and producing a growing number of professionals with information assurance expertise in various disciplines. Information assurance education plays a critical role in protecting the national information infrastructure. The Centers are key to having security solutions keep pace with evolving technology now and into the future. The Centers also provide great geographic dispersion of information assurance education across the country, building expertise where the national information infrastructures reside.

Osterweil honored with SIGSOFT award

Lee Osterweil, Professor and Dean of Natural Sciences and Mathematics, has received the 2003 ACM Special Interest Group on Software Engineering (SIGSOFT) Outstanding Research Award. The award recognizes Osterweil's seminal contributions to the development of the subfield of software process within the field of software engineering. Past winners of this prestigious award include:

1997 Barry Boehm (University of Southern California)
1998 David Parnas (University of Limerick /McMaster University)
1999 Niklaus Wirth (retired, ETH Zurich)
1999 Harlan Mills (one-time posthumous)
2000 Victor Basili (University of Maryland)
2001 Michael Jackson (Independent Consultant)
2002 Gerard Holzmann (Bell Labs)

Osterweil was presented with this top award for research in the software engineering community at the International Conference on Software Engineering (ICSE '03) in Oregon. He has also been invited to present a plenary keynote address at the Joint Ninth European Software Engineering Conference and 11th ACM SIGSOFT International Symposium on the Foundations of Software Engineering to be held September 3-5, 2003 in Helsinki, Finland.

Lee Osterweil

Who's in the news?

The Department once again attracted media attention for its research. Senior Research Scientist **Howard Schultz** was interviewed for an article in *DG.O,* an online publication of the National Science Foundation's Digital Government program (**www.digitalgovernment.org/news/**). The article details Schultz' work on multispectral image analysis and 3-D terrain mapping in a joint project with Professors **Ed Riseman** and **Allen Hanson,** and partners at Mount Holyoke College, Winrock International, Harvard, Duke, and the USDA Forest Service.

Graduate student **Brent Heeringa** was quoted in a *Springfield Union-News* article saying it is unlikely that a paperless society will come to fruition in the near future. **Kyle Rawlins,** an undergraduate researcher who works with Professor **Victor Lesser,** was featured in *UMass Magazine*. Rawlins talked about the value of research to an undergraduate's education.

David Hart, Executive Director of the Center for Computer-Based Instructional Technology (CCBIT), was also interviewed in *UMass Magazine*. The article focused on CCBIT's online web-based tutorial system (OWL). An accompanying article about the use of OWL for art history pictured Hart along with CCBIT staffer **Matthew Mattingly.** CCBIT also participated in the opening of the Goody Parsons witchcraft exhibit at Historic Northampton Sunday where the companion website created by CCBIT was publicly announced. Hart was quoted in the *Daily Hampshire Gazette* about the project. The local public radio station, *WFCR,* also featured a story about the Goody Parsons project.

A report on the online music recognition and searching (OMRAS) research of the Center for Intelligent Information Retrieval (CIIR) appeared in a recent issue of *D-Lib Magazine* (**www.dlib.org**), featuring graduate student **Jeremy Pickens.** While attending the International Symposium on Music Information Retrieval in Paris, Pickens was filmed by the *BBC World News* for a report on the OMRAS research. *The Economist* also featured UMass in an article about the music recognition research and software. A number of Internet news sites picked up the story as well.

AWARDS

Levine selected as Lilly Teaching Fellow

ASSISTANT PROFESSOR BRIAN LEVINE has been selected as a University of Massachusetts Lilly Teaching Fellow for the 2003-2004 academic year. Acceptance into the Lilly program is highly competitive, with about 30 applications each year for only eight awards.

This award program, established in 1986, enables promising junior faculty to cultivate teaching excellence. The Lilly Teaching Fellow Program is run by the UMass Center for Teaching (CFT).

For his Lilly project, Levine will address the problem of creating new undergraduate courses for which there are currently no appropriate textbooks. His approach will be based on the use of collaborative wiki web sites. A "wiki" is a web site specifically designed so that content can be added extremely quickly by students, even non-computer scientists. During the semester, as the class gathers sources and gains experience in the new course content, students will add to topics on the web site in light of what they have learned. "My aim is to create an on-line community-based textbook for the course so that I can offer the class to more students the following year," says Levine. Levine has already started this process as a trial with graduate students by co-teaching the Systems Building for Mobile Devices course (CMPSCI 691Q) with previous Lilly Fellow Assistant Professor Prashant Shenoy.

Previous Lilly Teaching Fellows in the Department include Prashant Shenoy (2001-2002), James Allan (1999-2000), Ramesh Sitaraman (1996-1997), David Mix Barrington (1994-1995), Jim Kurose (1993-1994), and Eliot Moss (1991-1992).

Kurose receives education and service awards

PROFESSOR JIM KUROSE has received this year's Taylor L. Booth Education Award, the highest award in education given by the Institute of Electrical and Electronics Engineers (IEEE) Computer Society. In addition, Kurose is one of six faculty from across the five-campus system to receive the UMass President's Public Service Award in recognition of their contributions to the Commonwealth. For the prestigious IEEE Taylor L. Booth Education Award, Kurose will receive a bronze medal and honorarium for his outstanding record in computer science and engineering education.

With nearly 100,000 members, the IEEE Computer Society is the world's leading organization of computer professionals. Founded in 1946, it is the largest of the 36 societies of the IEEE.

Kurose adds the Taylor Booth recognition to his many other teaching awards, including nine consecutive Outstanding Teaching Awards from the National Technological University, an Outstanding Teaching Award from the Northeast Association of Graduate Schools, and the UMass College of Natural Sciences and Mathematics Outstanding Teaching Award.

The annual UMass President's awards are bestowed upon faculty members who have used their academic or professional expertise to address a priority need of the Commonwealth. The award was presented to Kurose by President William M. Bulger and Board of Trustees chair Grace Fey.

Kurose and Joseph Goldstein, dean of the College of Engineering, received the award for conceiving, planning, and developing support for the Commonwealth IT Initiative (CITI). They succeeded in engaging almost all of the 29 institutions of public higher education in the project.

Immerman .....

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"Neil is a pioneer in theoretical computer science research," said Department Chair Bruce Croft. "He certainly deserves these honors."

The John Simon Guggenheim Memorial Foundation announced that Immerman, along with three other UMass professors, was a recipient of the seventy-ninth annual competition. Guggenheim Fellows are appointed on the basis of distinguished achievement in the past and exceptional promise for future accomplishment.

Immerman is one of the key developers of an active research program called descriptive complexity, an approach he is currently applying in model checking, database theory, and computational complexity theory. He received his Ph.D. from Cornell University and has been on the faculty of the University of Massachusetts Amherst since 1989. Immerman is an editor of *Information and Computation* and the *Chicago Journal of Theoretical Computer Science*. In 1995 he was awarded, jointly with Róbert Szelepcsényi, the Gödel Prize in theoretical computer science. Immerman joins previously named UMass Computer Science ACM Fellows W. Richards Adrion, Lori Clarke, W. Bruce Croft, Robert Graham, James Kurose, Leon Osterweil, Krithi Ramamritham, Arnold Rosenberg, and Donald Towsley.

The ACM Fellows Program was established in 1993 to recognize and honor outstanding ACM members for their achievements in computer science and information technology and for their significant contributions to the mission of the ACM. The ACM is the oldest and largest society for computing and technology professionals worldwide. Immerman will be inducted at an ACM awards banquet on June 7, 2003 in San Diego, California.

RESEARCH

Think too much

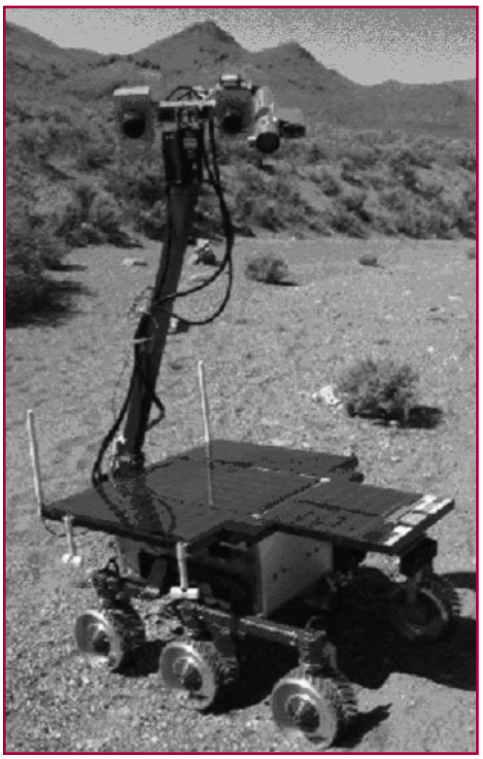
(from page 1)

round-trip time for communication makes tele-operation infeasible. So, the rover must operate autonomously and must be equipped to make good and timely decisions. The Sojourner rover in 1997 was the first planetary rover to operate under such constraints and thus represents the point of departure for rover autonomy.

Planetary rovers are faced with a great deal of operational uncertainty: exactly how long operations will take, how much power will be consumed, and how much data storage will be needed. There is also uncertainty about environmental influences such as the rate of battery charging or which scientific tasks are possible. To allow for both sources of uncertainty, sequences are typically based on worst-case estimates and contain fail-safe checks. If an operation takes less time than expected, the rover waits for the next time-stamped operation. If operations take longer than expected, they may be terminated before completion. In some cases, all non-essential operations may be halted until a new command plan is received. These situations result in unnecessary delays and lost opportunities.

Zilberstein's research aims to increase the productivity of the rover under the constraints of action, environmental uncertainty, and limited computational resources. To this end, the lab is pursuing a program of increasing capabilities, starting from the capabilities of the Sojourner rover and moving toward autonomous goal selection and ordering. New planning and execution techniques allow the rover to re-prioritize and reorder scientific activities based on progress made, scientific observations, and the success or failure of past activities. The solution relies on off-line analysis of the problem and on pre-compilation of control policies.

The rover planning problem can be formalized as a Markov decision process (MDP), a framework that is widely used for stochastic planning and reinforcement learning. MDPs describe a domain in terms of its possible states, the possible actions that can be taken, the possible outcomes of these actions, the cost of executing actions, and the expected benefits of achieving certain goals. A solution provides the agent with a policy or plan of action that maximizes goal achievement. The complexity of classical dynamic programming techniques for solving MDPs is polynomial in the size of the state space. However, the size of the state space grows exponentially with the number of state variables. This "curse of dimensionality" has limited the applicability of MDPs in such domains as autonomous rovers. The RBR lab has developed a number of algorithms and techniques that make it possible to address this challenge.



The "K9" experimental rover used at NASA Ames Researvh Center. UMass graduate students have used K9 during their summer internships

Work of lab members, particularly Eric Hansen (Ph.D. '98) and current graduate student Zhengzhu Feng, has focused on exploiting domain structure and abstraction to scale up algorithms for solving MDPs. The algorithms employ symbolic model

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RBR News

Associate Professor Shlomo Zilberstein has been selected to form an INRIA-associated research team at UMass Amherst. The team will include several faculty members in the Computer Science Department who will collaborate with Dr. Francois Charpillet and his MAIA ("Machine Intelligente et Autonome") laboratory at INRIA-Lorraine (France). A total of eight research teams have been selected by INRIA, an AI research institute, for three-year collaboration projects. Four of the teams are from U.S. universities including UMass. The collaboration will focus on the development of decision-theoretic techniques for coordination of multiple autonomous systems. Funding from INRIA will facilitate the collaboration by supporting the exchange of senior researchers and graduate students between the two institutions for short and long visits.

In other news, Zhengzhu Feng, a Resource Bounded Reasoning (RBR) Lab graduate student who works on the rover project, has been selected to participate in the highly competitive 2003 NASA Ames/RIACS Summer Student Research Program (SSRP). NASA Ames Research Center (Ames) and the Research Institute for Advanced Computer Science (RIACS) invite highly qualified applicants to the SSRP. NASA Ames has been designated the NASA Center of Excellence for Information Technology. SSRP provides an opportunity for students to gain experience and expertise solving challenging problems at the forefront of information technology and space science. Feng follows Dan Bernstein and Max Horstmann who have participated in the program and have each spent a summer at NASA Ames Research Center working with NASA researchers and evaluating their work with an actual experimental rover. "I am very pleased that a third member of the lab has been selected to participate in this wonderful internship program. It allows us to better understand the technical problems that NASA researchers are tackling and thus increase the impact of our research in this area," says Zilberstein.

CENTERS

CCBIT hosts National Teacher Training Institute

SIXTY K-12 EDUCATORS FROM AROUND THE STATE gathered at the UMass Amherst Computer Science building for the tenth annual National Teacher Training Institute (NTTI) conference hosted by public television station WGBY in Springfield, the School of Education, and the Center for Computer-Based Instructional Technology (CCBIT). The conference featured 10 NTTI "master teachers" presenting lessons to small groups of colleagues. The primary goal of the lessons is to infuse technology – including video – into best instructional practice.

This was the first year the conference was held at Computer Science, and Sarah Cothran, education manager for WGBY, deemed it a success. "The aura of having it here provided a sense to teachers that they were in a university environment that fostered and encouraged their learning," Cothran remarked.

NTTI is sponsored by WNET, the public television station in New York City, and is supported by the Cisco Foundation and the GE Fund. WGBY in Springfield is one of 26 NTTI sites nationally, and one of just a handful of NTTI satellites to partner with a local university. NTTI teacher participants are given a teaching methodology to follow that calls for the true integration of technology tools into teaching practice rather than simply using computers and videos as a way to occupy a student's time.

The activities presented this year ranged from the construction of bridges out of newspapers in conjunction with an interactive website that explored the concepts of tension and compression to the use of the UMass Center for Knowledge Communication's (CKC) intelligent tutoring program AnimalWatch (developed by Psychology Professor Carole Beal and Computer Science Research Associate Professor Beverly Woolf) to assist elementary-age students in acquiring math skills. The day included a four-part keynote speech by David Hart, executive director, and Paul Oh, K-12 project director, of CCBIT; and Dr. Robert Maloy and Ruth Verock-O'Loughlin from the UMass School of Education. Both CCBIT and the School of Education have been partnering with WGBY to provide an innovative professional development model for the NTTI teachers, something new to the project this year.

In the fall, Dr. Maloy identified teachers to participate in the NTTI program who were not necessarily well-versed in the use of instructional technology and most of whom identified themselves as "not very comfortable" in utilizing technology. He then appointed technology "coaches," or mentors, to work with the NTTI teachers. The coaches provided their teachers with assistance in the classroom by researching websites, meeting to discuss teaching strategies, reviewing lesson plans, and helping to prepare for the NTTI conference presentations.

Dr. Maloy and Hart are also principal investigators for a Massachusetts Board of Higher Education grant that calls for the continued implementation of this coaching model with a new round of K-12 teachers next year.

Sarah Cothran, education services manager of WGBY, noted that the event marked the first time the Springfield public television station has enjoyed such a wide-ranging collaboration. "It was a pleasure to work with two totally separate departments in the same university. We were working with the School of Education and CCBIT towards a common goal: to benefit the teachers of the region."

UMass School of Education's Dr. Robert Maloy greets teachers during a keynote address.

CCBIT's David Hart demonstrates the intelligent-tutoring software program AnimalWatch.

Turner's Falls High School teacher Lawrence O'Brien uses a PBS video to emphasize a point about the National Labor Relations Act.

Westhampton Middle School teacher Irene Laroche uses a British Broadcasting Company website to shape a discussion on the Arab-Israeli conflict.

University of Massachusetts Amherst

Alum Matters

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A newsletter for alumni of the Department of Computer Science

A successful venture for A. Anthony Gee

A. Anthony Gee's (BS '90) venture capital firm, Carthage Venture Partners, derived its name from the ancient city-state in North Africa that was a rival to Rome and the birthplace of Hannibal. In 217 BC, Hannibal set out to invade Italy with a small force of hand picked troops, crossed the Alps with a full baggage train and elephants, and overran the Roman force with his cavalry, leaving Rome nearly defenseless. Gee's partnership has also set out to conquer a rival – the low success rate for early stage software start-ups.

Gee and his partners were inspired by Hannibal's ingenuity, commitment, and tactical prowess. The Carthage team feels that they have the same right stuff as Hannibal - a graceful combination of tenacity, teamwork, and contextual skills. "Carthage is the embodiment of our entrepreneurial, financial, and technology skills," says Gee. Along with Carthage Ventures, Gee himself has been on a career path to success. He is currently the managing partner of the New York City-based venture capital firm that he founded in 1996 along with UMass Amherst Engineering alumnus Charles A. Sheffield and one other.

Carthage invests in the companies that have the most promising business plans for success, but that others may have overlooked. One of the company's funds, Carthage's Venture Fund LP, is a limited partnership that was formed to make equity and equity-related investments in information technology and communication companies. The Fund was formed in January 2001 and was capitalized by institutional investors with $15.15 million. While the fund is still in its early stages, it has achieved success. Though Carthage tends to invest in companies where the product is already developed and where a few customers are already in place, it still considers compelling companies at an earlier stage. One of the Fund's most successful early stage portfolio companies is B2eMarkets. Carthage was the first institutional investor in B2eMarkets, a company that employed only its two founders and had no customers. Now the company has about 100 employees, is considered the leading strategic e-sourcing company by many analysts, and its customer list includes Ford, Delta, Hewlett Packard, Merck, and 3M. "It is very fulfilling to see a company go from vision to a leading enterprise," says Gee.

A. Anthony Gee

Having been together since 1996, Gee and his partners have formed a bond that transcends business and allows them to tap into the strengths of each other so that they never feel alone. "Running your own firm is exhilarating, challenging, and sometimes just plain scary," says Gee. "Getting started is always the most difficult part of any venture." Gee's firm was fortunate to find some mentors and investors that believed in them and their vision, and that gave them the opportunity to get started. Today, in this challenging market environment, those same early believers are still with Gee and his partners in the form of investors and advisory board members. "I think that if anyone knew ahead of time how difficult the road to starting and building a firm from scratch would be, many firms would not have been started," says Gee. "However, once you are in the middle of it, it becomes very hard to turn back."

Turning back is something that Gee has no plans to do. Even with a downturn in the economy, there are still good investments to be made and new challenges to overcome. He believes that now is actually a good time to invest because valuations, the price of investments, are low.

The challenging part for Gee right now is "exiting" investments. As investors, they have to, at some point, receive a return from their investment. This typically comes about through an initial public offering (IPO) or a sale of the company. Because of the tough economic environment, both are very difficult right now. It is also difficult for Carthage's portfolio companies to sell their products to Global 1000 corporations. When these companies can't sell products, their revenue decreases and then they typically need more venture funding. This puts significant pressure on both the company and its investors.

Gee knows well the pressure of running a business, but he decided early on that he wanted to be an entrepreneur. He graduated from UMass Amherst with a bachelor's degree in Computer Science in 1990. While at UMass, Gee was a National Science Foundation Scholar. He enjoyed his experience at UMass. "I was very active in social issues and campus politics," says Gee. "I think the multitude of experiences allowed me to become a well balanced individual." While at

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Alumni Connections

Satinder Singh (Ph.D. '93) became as Associate Professor at the University of Michigan in Fall 2002. Prior to joining Michigan's Electrical Engineering and Computer Science department, Singh spent a year as chief scientist of Syntek-Capital, a global venture capital company. While at UMass Amherst, Singh was advised by Professor Andrew Barto.

Two of Professor Victor Lesser's former students have also recently received tenure. **Norman Carver** (Ph.D. '90) received tenure from Southern Illinois University Carbondale and **Keith Decker** (Ph.D. '85) received tenure at the University of Delaware. Carver is an Associate Professor in the Department of Computer Science at SIUC and Decker is an Associate Professor in Delaware's Department of Computer & Information Sciences.

Jonathan Vos Post (M.S. '75), was recently teaching in the Computer Science Department at California State, Los Angeles and also was an adjunct professor in Astronomy at Cypress College. One of Vos Post's current ventures is his web domain, Magic Dragon Multimedia (**http:// magicdragon.com**), which is in its eighth year and gets over a million hits per month. Vos Post can be contacted at jvospost @hotmail.com.

Sandholm receives awards for scientific achievement

Tuomas Sandholm, (Ph.D. '96), has received two of the scientific community's prestigious awards: the Computers and Thought Award, presented by the International Joint Conference on Artificial Intelligence (IJCAI), and the Sloan Research Fellowship, presented by the Alfred P. Sloan Foundation.

As the honoree of the 2003 IJCAI Computers and Thought Award, Dr. Sandholm will be a featured lecturer during the 2003 IJCAI Conference in Acapulco, Mexico. The award is presented every two years to a prominent young scientist working in the field of artificial intelligence. First presented in 1971, the award has recognized the efforts of 17 leading scientists.

As a 2003 Sloan Research Fellow, Sandholm receives a two-year grant. The Sloan Foundation currently awards 112 fellowships each year. Twenty-six Sloan Fellowship recipients have gone on to win the Nobel Prize.

Sandholm is Associate Professor in the Computer Science Department at Carnegie Mellon University and recently received tenure. At CMU, he is also the Director of the Agent-Mediated Electronic Marketplaces Lab. He received his Ph.D. and M.S. degrees in computer science from UMass Amherst, studying with Professor Victor Lesser. Sandholm has published more than 130 technical papers. He has also received several academic awards including the 2001 ACM Autonomous Agents Research Award and the 1997 National Science Foundation Career Award.

Sandholm is the founder, chairman, and chief technology officer of CombineNet (**www.CombineNet.com**). Leading companies such as Bayer Corporation, PPG Industries, Heinz, and Procter & Gamble are using the company's combinatorial optimization technology for strategic sourcing and procurement. For more information, contact Sandholm at sandholm@cs.cmu.edu.

In memoriam

Karen (Erickson) Huff (Ph.D. '89), died at the age of 56 on June 21, 2002, at her home in Winchester, MA after a lengthy battle with cancer. Huff was a researcher, project leader, and department manager in the advanced software laboratory at GTE Laboratories in Waltham, MA. She had a strong interest in applying emerging technology to improve software engineering and business practice, and authored many technical papers on these subjects. Prior to GTE, Huff was a software engineer and project leader in the compiler division at Intermetrics, Inc. in Cambridge, MA. She enjoyed early New England architecture, was a student of the textile arts, and was an accomplished spinner and handweaver. Her experiments applying computer graphics to textile design were featured in *Computer World Magazine*.

Gee . . . . . *(from page 6)*

UMass, he developed strong relationships with UMass administrators such as Rick Townes, former Assistant Vice Chancellor for Student Affairs, and former Chancellor Joe Duffy. Gee still sees Duffy in Washington D.C. from time to time.

When asked what advice he had for students and graduates to help them compete in the business arena, Gee responded, "I think the three most important things that I can tell students and graduates are:

1. Be passionate – It is not enough just to be talented, or to work hard. To truly be successful, it takes passion.

2. Learn to communicate effectively – As scientists, we don't focus enough time or energy on our communication skills. Learn how to communicate the good and the bad effectively and succinctly.

3. Develop durable relationships – Your ability to establish and maintain relationships will ultimately determine how far you go."

For academics interested in attracting investors, Gee advises them to work at understanding and articulating what the true market opportunity is for their business. "VCs [venture capitalists] like to see a dedicated management team, a technology that is not easily replicated, and a market that is very large," says Gee.

Gee feels that his degree in computer science gives him the foundation to understand the world of technology and in turn operate in the world of business. "In venture capital, technology and finance are tightly coupled," says Gee. "The first thing I must do is understand the technology and then understand the technology's potential economic impact." Since most high tech venture capitalists have a computer science or engineering undergraduate degree and an M.B.A., Gee followed that same path.

He decided to pursue an M.B.A. while working at his second job after graduating from UMass Amherst, a technology think-

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RESEARCH

Theorists develop methods for optimal shared computation

The Theoretical Aspects of Parallel and Distributed Systems (TAPADS) group will soon publish two research results that have important implications for the efficient scheduling of shared computation in heterogeneous clusters and over the Internet. TAPADS Professors Micah Adler and Arnold Rosenberg, together with graduate student Ying Gong, have developed an algorithm for scheduling heterogeneous clusters of workstations that guarantees optimal performance for a large class of computations. Rosenberg has also developed a new mathematical model of computations shared among geographically dispersed partners (a Computational Grid). He has applied the model to demonstrate an optimal scheduling policy for a particular form of scientific computation in the Grid.

Scheduling in a heterogeneous cluster

Clusters of processors (workstations, PCs, or others) promise to make parallel computing available at affordable prices. However, efficiently using a cluster as a parallel computer is much more challenging than using a "multiprocessor in a box," especially when the cluster is heterogeneous in the sense that its processors differ in computing power (perhaps because they were purchased at different times). The algorithm of Adler, Gong, and Rosenberg produces an optimal schedule no matter how great the disparities in computing power among the cluster members.

One processor acts as cluster coordinator and delegates computing tasks to the other processors, which perform the requested computation and report the result back to the coordinator. The coordinator has a large "bag" of mutually independent tasks that are all of equivalent complexity, so the cluster never runs out of work. The coordinator decides how much work to give to each processor in the cluster, and when to send it over the local area network (LAN). Taking into consideration the computing power of each processor and the time required for communication over the LAN, the coordinator can predict when each processor will finish its assigned tasks and report back its results. The coordinator can communicate with only one machine at a time.

Suppose the coordinator has dedicated access to the cluster for a fixed period of L time units. How does the coordinator allocate tasks to the other processors to maximize the total number of tasks completed during the access period? Intuition suggests that if processor P_1 is much faster than the others, the coordinator should give P_1 enough work to keep it computing for the longest possible time. The longest possible time P_1 could work is L minus the time required for transmitting work to P_1 and getting results back from P_1. Then the coordinator sends tasks to the second fastest processor P_2 and tries to keep P_2 busy as long as possible. The intuitive strategy yields a schedule that has a Last In, First Out (LIFO) structure, depicted in Figure 1(a) for a cluster of 4 processors. P_0 is the cluster coordinator. Each horizontal line corresponds to one processor in the cluster. The shaded section of the line represents the period when the processor is computing tasks from the bag. The unshaded sections represent the time required for computation related to communication and for transmission across the network.

Adler, Gong, and Rosenberg have proved that the intuitive LIFO schedule is not optimal. Provided the access period L is long enough, the optimal schedule is one that maximizes the parallelism of all the processors, even the slower ones. This strategy yields a schedule that has a First In, First Out (FIFO) structure (Figure 1(b)). There is no need to start the processors in decreasing order of computing power, as in the LIFO strategy. Any permutation of the starting order is equally efficient.

So long as the access period is sufficiently large, the FIFO scheduling strategy is optimal for a cluster of any size, no matter how great the disparities in computing power among its members (including the case of zero disparity, a homogeneous cluster). Yet many professionals in the field of parallel computing would choose the LIFO strategy for highly heterogeneous clusters. In this case their intuition leads them astray.

Scheduling in a Computational Grid

A Computational Grid is a more general concept of collaborative computing than a cluster of workstations. The Computational Grid (CG) is a collection of geographically dispersed sites that have agreed to share their resources. While the members of a cluster share only CPU cycles, the members of a CG share not only CPU cycles but also disk storage and other resources. Cluster members are connected by a LAN; CG members are connected via the Internet.

Scheduling a shared computation in a CG is more difficult than scheduling in a cluster because it is impossible to anticipate when results will be returned from a task that has been sent to a CG partner. Members of the CG are obligated to accomplish computational tasks they receive from other members, but there are no constraints on how much time they might take to fulfill the request. Communication delays over the Internet are unpredictable.

When the tasks to be shared are interdependent the scheduling problem

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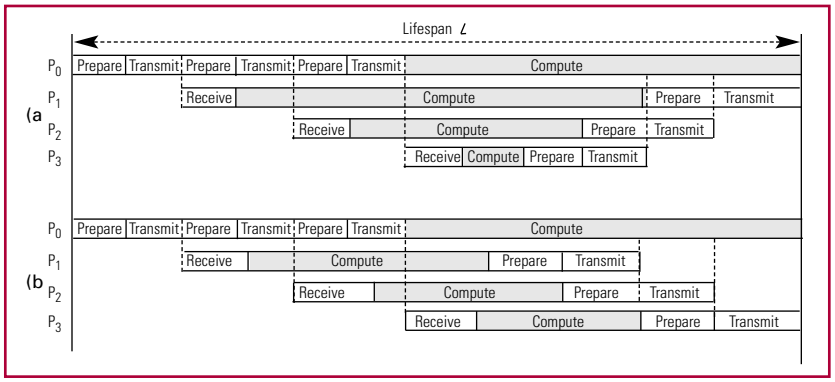


Figure 1: (a) LIFO and (b) FIFO scheduling strategies for a cluster of four processors. P_0 is the cluster coordinator. *Figure is not drawn to scale.*

RESEARCH

Theorists ..... *(from previous page)*

becomes yet more challenging. A task can get blocked from execution if it is dependent on the results of tasks that have been sent out to CG partners, but not yet completed and reported. The owner of the shared computation has to keep as many tasks as possible eligible for execution (all dependencies satisfied) to avoid running out of work while waiting for results to come back from tasks previously delegated.

Rosenberg has devised a new mathematical model for the CG scheduling problem: a variety of pebble game. Pebble games have been used in previous research to model task allocation in multiprocessors and related problems. The game is played on a directed acyclic graph (DAG) by a single player. The nodes of the graph correspond to computational tasks and the edges of the graph represent dependencies among those tasks. The player has two kinds of pebbles: *E* pebbles for tasks that are eligible for execution, and *X* pebbles for tasks that have already been executed. The player can put an *E* pebble on any task whose parents in the DAG have *X* pebbles. The player can replace any *E* pebble with an *X* pebble. The goal of the game is put an *X* on every node of the DAG, while maximizing the number of *E* pebbles as a function of the number of *X* pebbles. This corresponds to the CG scheduler's goal of finishing the overall computation while maintaining at all times a pool of eligible tasks that can be sent out.

Rosenberg applied his model to a form of scientific computation that arises frequently in meteorology and geology, among other disciplines. The task dependencies form a rectangular mesh as shown in Figure 2. Rosenberg proved that the optimal strategy for scheduling a computation of this form in a CG is to allocate tasks along each diagonal of the mesh. The schedule begins with the node in the southwest corner of the grid that has no dependencies, and proceeds diagonal by diagonal towards the northeast. Along each diagonal, the tasks should be allocated in order from northwest to southeast or vice versa. This strategy maintains the highest possible number of eligible tasks and ensures that no task will be overlooked.

The pebble game model is equally applicable to DAGs with different topologies. Professor Rosenberg is currently extending the model to dependency structures that have the form of trees and pyramids.

The paper by Adler, Gong, and Rosenberg about scheduling heterogeneous clusters has been accepted for presentation in the 15th ACM Symposium on Parallelism in Algorithms and Architectures (SPAA). Rosenberg will present his work on scheduling in Computational Grids at the 17th International Parallel and Distributed Processing Symposium (IPDPS).

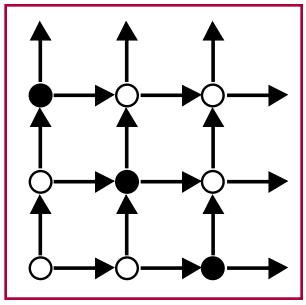


Figure 2: Rectangular mesh representing task dependencies in a computation. The optimal scheduling strategy allocates eligible tasks along each diagonal (black nodes).

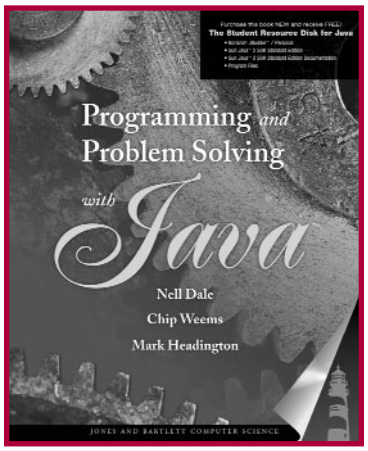
Think too much ... *(from page 4)*

checking (SMC) representations, which were originally studied and used in the field of circuit design and verification. Guided by some heuristic function, the algorithm systematically prunes away abstract states that are not reachable by the optimal policy, and performs computation only on the relevant abstract states. As a result, a solution can be found without necessarily visiting the whole state space and without enumerating the relevant part of the state space. Further, by pruning, more state abstraction can be obtained in the remaining state space since values of unreachable states are ignored. The resulting algorithm is able to find exact solutions for some test MDPs with more than 1025 states, which has never been accomplished before.

Typical algorithms that solve MDPs produce a plan represented as a policy that maps states to actions. Such policies are provably optimal with respect to the probabilistic model used, but they are not easy for people to understand. This drawback has limited NASA's willingness to adopt MDP planning. Instead, the 1997 Sojourner rover only executed a sequence of time-stamped low-level actions. This method provides maximum safety, but it lacks efficiency. The average downtime due to plan failure has been estimated at 50- 70 percent. To make MDP policies more understandable and more acceptable for future rover missions, graduate student Max Horstmann developed a technique for converting MDP policies to a more understandable graphical representation based on contingency plans.

Using multiple, simpler, and cheaper rovers instead of a single rover is beneficial because it increases the autonomy, productivity, survivability, and efficiency of the mission, but extending MDPs to solve the decentralized planning problem presented by multiple rovers is a serious challenge. Graduate student Dan Bernstein, in collaboration with Professor Neil Immerman and Purdue University Professor Bob Givan, has analyzed this problem and proved that the complexity of decentralized MDPs is NEXP-hard (Non-deterministic Exponential-time hard). This means that deriving optimal plans for two or more cooperating rovers could be extremely difficult. Members of the RBR lab have identified some useful classes of decentralized MDPs that can be solved optimally. Graduate student Raphen Becker, in collaboration with Professor Victor Lesser, has produced one such algorithm that is particularly suitable for coordination of multiple rovers. The technique is the first to solve optimally a class of decentralized MDPs. Additional exact and approximate algorithms are under development.

Zilberstein received a B.A. in Computer Science from the Technion – Israel Institute of Technology, and a Ph.D. in Computer Science from the University of California at Berkeley. In 1993, he joined the UMass Department of Computer Science where he directs the Resource-Bounded Reasoning Laboratory. The laboratory conducts research in approximate reasoning, decision-theoretic control, design of autonomous agents and multi-agent systems, heuristic search, information gathering, monitoring and control of computation, planning and scheduling, reinforcement learning, and reasoning under uncertainty. Zilberstein has received an NSF Research Initiation award (1994), an NSF Career award (1996), the European Conference on AI Best Paper Award (1998), the Lady Davis Visiting Associate Professorship at the Technion (2000), and an NSF ITR award (2002).



NEWS

Weems publishes 17th book

Associate Professor Chip Weems' 17th book was recently released. *Programming and Problem Solving with Java* is a 789-page collaboration of Nell Dale, Chip Weems, and Mark Headington.

The book is a more traditional approach to presenting Java than his previous book on that language, *Introduction to Java and Software Design,* released in January 2001. "We found that although many schools are switching to Java, they are not embracing the event-driven programming model, and are using the language with traditional console I/O to teach programming based on the basic control structures of sequence, branch, loop, and call," says Weems. "*Programming and Problem Solving in Java* is meant to address the needs of this audience."

Although it is more traditional in its organization, this new book still innovates by emphasizing object-oriented design (OOD) from the very beginning. While many introductory programming texts claim to be object-oriented, they do not actually develop object-oriented design concepts until several chapters into the book. "This uneven presentation makes it more difficult for the students to grasp and apply the many concepts of OOD," says Weems.

The authors' approach in this new book gradually builds up an understanding of OOD from the very beginning. In each chapter, the students add to their knowledge and skills in developing object-oriented applications, thus continuously growing in their understanding of the paradigm.

This is Weems' first full-color book. Programming texts have traditionally used only black and a second color. But now, with widespread use of development environments that use color coding of program text, some publishers have decided to invest in full color. "For me, this opens up a wide range of pedagogical opportunities that I have been wanting to try for years," says Weems. "Color is also an essential tool in holding the attention of students who have grown up in an environment in which they have become accustomed to strong visual stimulation."

In addition to his steady pace of publishing, Weems also co-directs the Architecture and Language Implementation Group with Associate Professor Eliot Moss. His research interests include associative processing and architectures, parallel architectures to support computer vision and image processing, vision benchmarks for parallel processors, heterogeneous parallel architectures and their compilers, and integration of compile-time and runtime information in high-performance microprocessors. More information on the book, published by Jones and Bartlett Publishers, Inc., can be found at **http://catalog.jbpub.com**.

Gee *(from page 7)*

tank called New Science Associates (later acquired by Gartner Group). At New Science, Gee's particular area was Applied Intelligent Systems (artificial intelligence). He advised major corporations regarding the outlook for deploying new leading-edge technologies. While he had a good understanding of the technology, he really had little understanding of how to evaluate these venture-backed companies that were providing most of the technology. At that point, Gee decided that he wanted an M.B.A. and also wanted to learn more about venture capital. He went on to receive his M.B.A. in finance from New York University's Stern School of Business, where he was an NYU Graduate Fellow.

After receiving his M.B.A. , Gee went to work for Salomon Smith Barney in New York City doing IPOs for technology and communication companies. As a result, he was able to build many relationships in the metro-NY area. After leaving the investment bank, he decided that he wanted to do something more entrepreneurial, so he joined New York Online, a NY-based technology consulting firm, and served as Chief Financial Officer and Senior Consultant. Gee quickly realized that, to get venture capital, he needed to make trips to Boston and the West coast. At that time, venture capital in New York was hard to come by. Even today, although New York is a financial center, there remain relatively few venture capital firms in New York, compared to Boston and the Silicon Valley. Most of the other private equity firms focus on corporate buy-outs and not venture capital, says Gee. But given the allure of the city and the contacts he had made there, Gee chose to stay in New York.

When not working, Gee spends his time with his wife Jennifer, and two children, four-year-old daughter Kai and three-month-old son Khari. He is also an avid golfer who is trying to get his handicap down to single digits.

While Gee has encountered a few UMass Amherst CS alumni in his travels, most have been engineering or business graduates. He would like to find out what other computer science graduates are doing. Gee can be contacted via email at gee@carthage.net or at Carthage Venture Partners, 145 West 57th Street, 9th Floor, New York, NY 10019. Perhaps there could be a new UMass partnership brewing in the future for Gee.

Omission

In the Fall issue of ***Significant Bits,*** we omitted three Computer Science Alumni from the list of people receiving National Science Foundation Information Technology Research (ITR) awards. Former students Amer Diwan (Ph.D. '97), Tony Hosking (Ph.D. '95), and Darko Stefanovic (Ph.D. '99) are participating as subcontractors in the UMass ITR project "Dynamic Cooperative Performance Optimization," led by Associate Professors Eliot Moss and Chip Weems, and former Associate Professor Kathryn McKinley. Diwan is currently an Assistant Professor at the University of Colorado Boulder, Hosking is an Associate Professor at Purdue University, and Stefanovic is an Assistant Professor at the University of New Mexico. Each is in the Computer Science Department of their respective universities.

Faculty News

Assistant Professor **Prashant Shenoy** is serving as the Program Co-chair for the ACM Multimedia 2003 Conference to be held in Berkeley, California in the fall. ■ The book *Language Modeling for Information Retrieval,* edited by Distinguished Professor **W. Bruce Croft** and Carnegie Mellon University Professor John Lafferty, was recently released by Kluwer Academic Publishers. The book is Volume 13 in the Kluwer International Series on Information Retrieval. ■ Professor **W. Richards Adrion** spoke to University faculty, staff, and students about "Funding Your Research from the National Science Foundaton." Adrion served as Director of the Experimental and Integrative Activities Division in the NSF's Directorate for Computer & Information Science & Engineering (CISE) from January 2000 to September 2002. He remains at NSF as a Senior Advisor to the Director of CISE on a part-time basis. ■ Research Assistant Professor **David Jensen** gave an invited talk to the National Research Council's Roundtable on Social and Behavioral Sciences and Terrorism. The talk, entitled "Data Mining in Networks," introduced members of the Roundtable to the basic ideas of knowledge discovery and data mining, and it presented technical ideas that should inform how data mining is applied to counter-terrorism. Members of the panel include Philip Heymann (Deputy Attorney General 1993-1994, Professor at Harvard Law School), Michael Chertoff (U.S. Assistant Attorney General, Department of Justice), and Jimmy Gurule (Under Secretary for Enforcement, U.S. Department of the Treasury). Jensen also gave an invited talk, "Data Mining in Social Networks," at the Symposium on Dynamic Social Network Analysis and Modeling, convened by the National Academy of Sciences' Committee on Human Factors.

Visitor News

Chikara Ohta has joined the Computer Networks Research Group as a Visiting Professor. Ohta is an Associate Professor at Kobe University, Japan. ■ University of Seville, Spain Associate Professor **Jesus Aguilar-Ruiz** is spending his sabbatical working with Professor **Paul Cohen** in the Experimental Knowledge Systems Laboratory (EKSL). ■ **Hirosama Nakatani,** Professor at the Shizuoka University in Japan, is a Visiting Professor with the Visions Laboratory. ■ **Zachary Rubinstein** (Ph.D. '02), Assistant Professor at the University of New Hampshire, is a Visiting Scholar working with Professor **Victor Lesser.** ■ A Visiting Scholar from the University of Paderborn in Germany, **Oliver Rohe** is working with the Laboratory for Advanced Software Engineering Research (LASER).

Research News

EKSL Senior Research Fellow **Clayton Morrison** and his wife Heather are the proud parents of a baby girl, Audrey Elise, born on January 13. Audrey's older sister Maya is two and half years old. ■ **Fuchun Peng** joined the Center for Intelligent Information Retrieval (CIIR) as a Senior Postdoctoral Research Associate.

Student News

Computer Science undergraduates **Adam Bellmore, Alex Dingle,** and **Michael Mammarella** won first place in the 2002 ACM Boston Preliminary Programming Contest (BOSPRE 2002) held at Harvard University. The team, coached by Assistant Professor **Micah Adler,** advanced to the ACM Northeast North America Regional Finals, held at the Rochester Institute of Technology, and placed seventh in that competition. ■ **Vanessa Murdock,** a Center for Intelligent Information Retrieval (CIIR) graduate student, won the best poster award at the Eleventh International ACM Conference on Information and Knowledge Management (CIKM). The poster, "Features of Documents Relevant to Task- and Fact-Oriented Questions," was also co-authored by Professor **W. Bruce Croft,** and Rutgers University's Professor Nick Belkin and graduate student Diane Kelly. ■ CIIR graduate student **Victor Lavrenko** is co-chairing the student session of the 2003 Human Language Technology/North American Chapter of the Association for Computational Linguistics (HLT-NAACL) conference to be held this spring in Edmonton, Canada. ■ Undergraduates **Lewis Theran, Richard Chang,** and **Cyrus Banerjee** received the 2002-2003 Microsoft Research Fellowships. ■ Computer Science undergraduate **Byn Choi** won third place in the 18th Annual Mathematics Competition run by the UMass Department of Mathematics and Statistics. CS undergraduates **Vitaliy Lvin** and **Subhash Patel** earned honorable mention in the competition.

Staff News

Sandi Harris Graves joined EKSL and the Knowledge Discovery Laboratory (KDL) as their Administrative Assistant.

352 and still counting

Something is missing in the Department, and a dozen faculty and staff are accomplices in the act. No, the missing item isn't computer equipment or office supplies (at least none that we know about), but instead is a loss of weight – a lot of weight – in the Department. Twelve people have collectively lost 352 pounds since beginning their battle of the bulge.

The participants that we surveyed include Judy Bardwell, Deb Bergeron, Laura Bishop, Oliver Brock, Priscilla Coe, Sergio Guzman-Lara, Laura Macsuga, Sharon Mallory, Leslie Marsland, Matthew Mattingly, Gwyn Mitchell, Kate Moruzzi, Ken Watts, and two other anonymous personnel.

While some in the Department are losing weight and exercising on their own, many have teamed up for support. In the computer science building, a daily exercise session is held for participants who log in seven miles of walking and 1.75 hours of aerobics per week. Two people have joined the group primarily to benefit from the exercise in order to enhance their general well being, rather than to lose weight. Twelve others have been very successful in losing weight, some with the help of professional weight loss organizations.

We aren't sure that this is what was meant when they said that they wanted to cut the fat in the University, but if it works for the weight loss participants, then that's all that matters.

Significant Bits

NEWSLETTER of the
DEPARTMENT OF COMPUTER SCIENCE
at the UNIVERSITY OF MASSACHUSETTS, AMHERST

140 Governors Drive
University of Massachusetts
Amherst, MA 01003-9264

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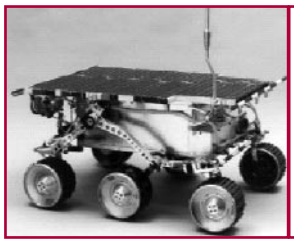

The Sojourner rover was the first to explore the surface of Mars in 1997

See story -- page 1

ART DIRECTOR .....Karen Chrisman, North Haven Design
FACULTY LIAISONS .....Rick Adrion, Bruce Croft, David Jensen, Prashant Shenoy
STAFF LIAISON .....Jean Joyce
GRADUATE STUDENT LIAISON .....Hannah Blau
CONTRIBUTORS .....Hannah Blau, *Campus Chronicle,* CombineNet, Deva I. Djaafar, A. Anthony Gee, Laura Macsuga, Paul Oh, *The Winchester Star*

GIFTS

Thanks for your support

THE FOLLOWING ALUMNI AND FRIENDS have actively supported the Department of Computer Science from August 2002 through March 2003. Such financial support is greatly appreciated and helps maintain a world-class instructional and research program. Contributions of alumni and friends help to fund important special activities that are not supported through the state budget.

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